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AUTHOR Stetten, Kenneth J.
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ABSTRACT

A low cost method for delivery of computer services to homes and schools through interactive television called time-shared, interactive, computer controlled, information television (TICCIT) has technical qualities such that it is individualized, computerized, multimedia, and provides unlimited points of entry and delivery of information. TICCIT's minicomputer facility, the computer subsystem, and some of the other hardware are described, and TICCIT's solution to the communications problem of awkward, expensive, or inefficient links from terminal to computer is discussed. The on-line terminal is described--a combination of a standard television receiver, a videotape recorder, and keyboard and control electronics. An explanation of TICCIT software discusses a special purpose monitor program supporting a number of user terminals and a tailored-to-subject-matter system of macro level commands to allow easy and efficient computer-assisted instruction authoring. (Author/SH)

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THE MITRE CORPORATION

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TICCIT: A DELIVERY SYSTEM DESIGNED FOR MASS UTILIZATION

KENNETH J. STETTEN, HEAD
COMPUTER SYSTEMS DEPARTMENT

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OCTOBER 1971

THE MITRE CORPORATION

ABSTRACT

The MITRE Corporation has invented a new, low cost method for delivery of computer services to homes and schools called TICCIT (Time-Shared, Interactive Computer Controlled Information Television). We believe it to be the first implementation of interactive television, a new communications medium having vast social implications. TICCIT hardware combines elements of television displays, video cassette tape recorders, cable television wideband transmission, and modern minicomputers and their peripherals. TICCIT software includes a special purpose monitor program supporting a large number of user terminals and a tailored-to-subject-matter system of macro level commands to allow easy and efficient computer assisted instruction authoring. The first complete curriculum planned for TICCIT is five full semesters of junior college courses including freshman mathematics, English composition and computer science.

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TICCIT: A DELIVERY SYSTEM DESIGNED FOR MASS UTILIZATION

1.0 INTRODUCTION

TICCIT (Time Shared Interactive Computer Controlled Information Television) is an interactive television system developed by the MITRE Corporation with the goal of proving that present day technology can provide a cost effective transition to mass utilization. A pilot version of this system has been and is being demonstrated in homes, schools, and businesses in Reston, Virginia. A dedicated version of the TICCIT system, which is specifically oriented toward serving as a computer assisted instruction system at the high school-junior college-university level, is being developed by MITRE under the sponsorship of the National Science Foundation. MITRE is developing both the hardware and sophisticated computer software. The University of Texas CAI Laboratory and Brigham Young University, subcontractors of MITRE, are developing the course material.

Telephone, radio and television were all breakthroughs in communication. History shows the social impact and dissemination speed of each was greater than its predecessor. We believe that interactive television will be the next, and in many ways, the most dramatic in the "great leaps forward" of media technology. Since interactive television's potential for public service transcends those of its predecessors, we feel confident in predicting that it will have an even greater social impact and spread even more quickly than any of these earlier forms of communications.

As shown in Figure 1, interactive television has a keyboard associated with each TV receiver as a computer entry device. The computer is programmed to interpret viewer key pushes in the context of what the viewer is watching. A key push may be interpreted in the context of a public meeting straw vote as a yea or nay; in a search for a new apartment as the number of bedrooms desired; in a course on

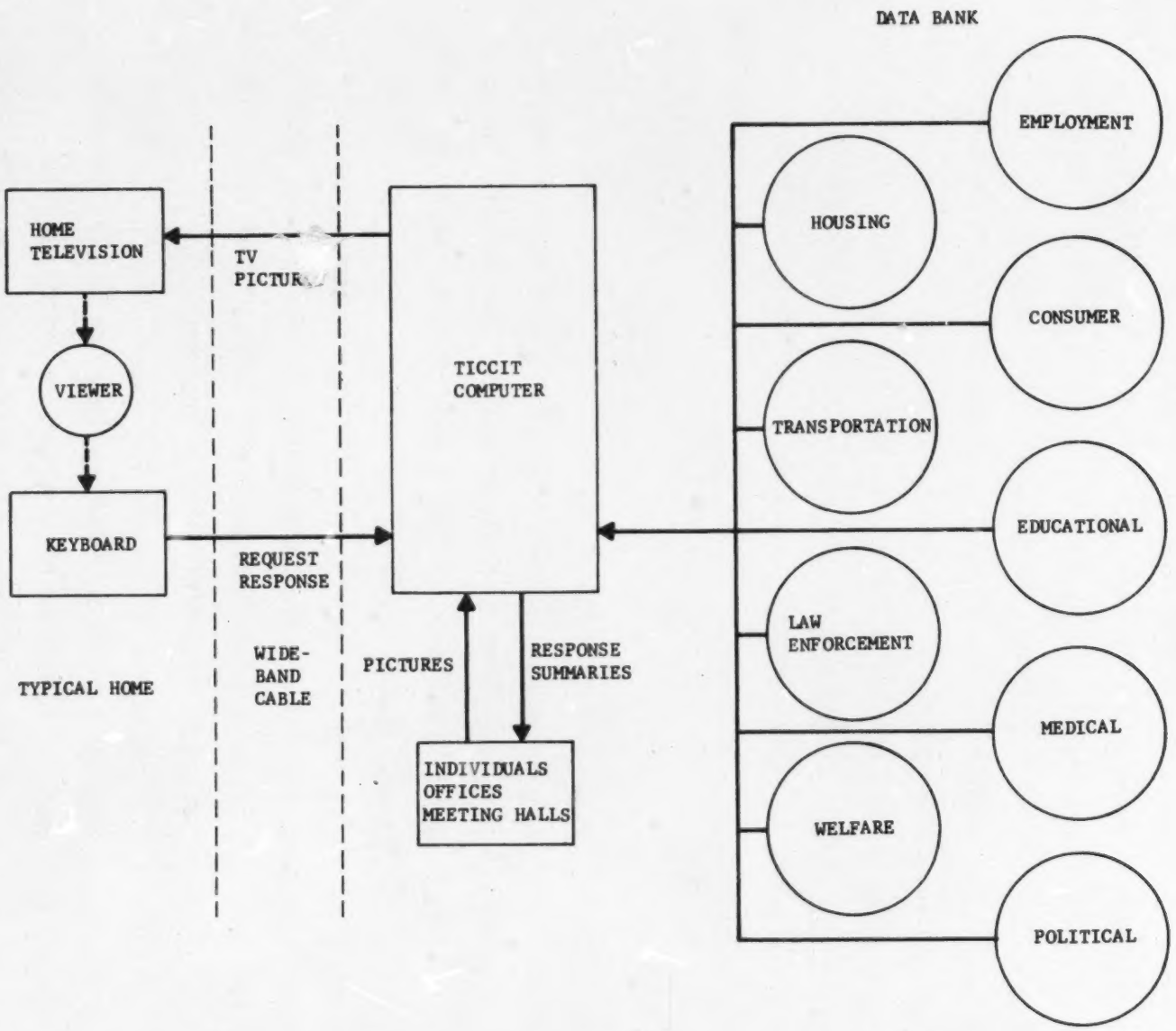


FIGURE 1
GENERAL PURPOSE TICCIT SYSTEM

home repairs as part of the answer to a question; etc. The keyboard is the viewer's means of interacting with the system.

The potential for explosive social impacts, we believe, follow from certain technical qualities:

(1) TICCIT can be low in cost, (our conservative estimates are 30 cents/terminal hour price, including generous operating profits) and uses mostly capitalized or planned consumer oriented technology.

(2) TICCIT is individualized. It responds "instantly" to the demands of each viewer, permitting him to receive detailed information economically and privately.

(3) It is computerized, offering search and calculation of information that might otherwise be difficult to obtain.

(4) It provides unlimited points of entry and delivery of information (similar to the advantages of the telephone and the mail); in addition, it offers controlled storage, access, and unparalleled speed and convenience of retrieval.

(5) It is multimedia, providing sight, sound, computer assistance all within one system and offering the potential of a common carrier between people (i.e., two-way videophone "snapshots").

Structurally, TICCIT is a multi-user computer system consisting of three major subsystems: a computer facility, user terminals, and the computer. The common characteristic of these three subsystems is the absence of new, expensive or exotic hardware.

MITRE is developing TICCIT to demonstrate a system that can provide new, socially relevant services at a commercially marketable cost. In designing TICCIT to meet this goal, MITRE has followed two guidelines:

(1) Maximize use of existing off-the-shelf commercial hardware, and

(2) Capitalize on rapidly advancing technology.

So far, the development effort on TICCIT has already:

(1) Led to the first demonstration of new economically feasible home-oriented interactive television services.

(2) Led to a design of a new, low cost, high performance hardware system and a unique new software approach to interfacing with the author's computer assisted instruction.

2.0 TICCIT'S MINICOMPUTER FACILITY

The size and capabilites of the TICCIT computer facility arose from a desire to find a marketable system that could ameliorate some of the social and educational problems confronting the country. What was looked for was a system which an individual school or cable TV operator could afford to lease and which at the same time could provide sophisticated display and computational capability. Our analysis led us to a modular approach for the computer facility. It was found that costs (per terminal hour) went up rapidly as the number of terminals decreased (below 100) and remained relatively level above 100. The basic TICCIT computer facility supports about 130 on-line terminals. In those cases where several hundred on-line terminals are required, multiple TICCIT computer facilities would be used. The total cost of the basic TICCIT computer facility is less than $200,000 today. Since the TICCIT system supports a dedicated task rather than general purpose data processing, its requirement for a management and operations staff is much smaller than that typically found in a standard computer system.

Figure 2 is a block diagram of the TICCIT computer subsystem. The computer subsystem separates foreground (terminal processing) and background (algorithmic frame processing) tasks with a minicomputer devoted to each task in order to balance and spread overall system I/O channel loads (with only one minicomputer the system would be I/O bound). Primarily, the terminal processor performs all fast reaction highly stereotyped functions interacting with the TICCIT student terminals. The main processor, utilizing the TICCIT data base, generates and assembles frames to be displayed as a function of courseware and student responses. Tasks of the main processor are diverse and relatively slow-paced relative to the tasks of the terminal processor.

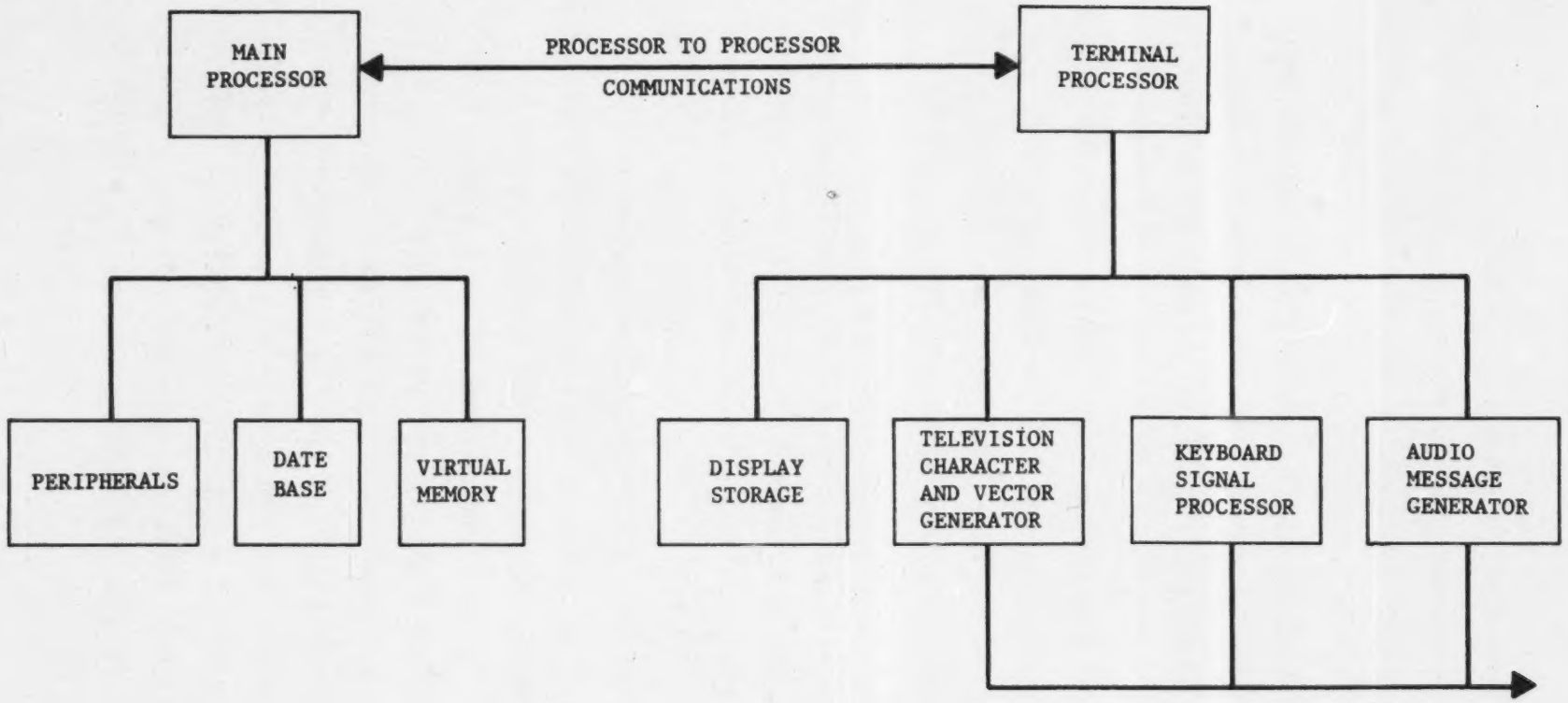


FIGURE 2
TICCIT COMPUTER SUBSYSTEM

The main processor (a Data General Supernova) is configured as a multiprogramming minicomputer with 32,000 words of core storage. It includes special hardware multiprogramming protection features, a host of standard peripherals, disc drives for the TICCIT data base, and a fixed head-per-track disc serving as a virtual memory. The peripherals (card reader, magnetic tape unit, line printer, and console CRT terminal) are all low or medium speed, low-cost items suited for both courseware development as well as use in student and other user delivery applications. The TICCIT data base is stored on two IBM compatible, removable media, movable head disc memories. Between these memories, 50 million characters may be stored and accessed. Through the use of special software, the high speed fixed head discs are used to implement a large virtual memory in which major parameters and program data for each terminal are stored.

The terminal processor, a Nova 800, is a type of minicomputer similar to the main processor but without special multiprogramming hardware and with less core memory. The terminal processor, as its name implies, services the terminals by receiving and processing keyboard entries and by generating new displays to be sent to the terminals. In addition, the capability exists for the processor to control an audio response subsystem. Two fixed head discs provide rapid access storage of previously output frames for subsequent editing and retransmission (for instance, echoing characters to the students' terminals as they are typed). The terminal processor's teletype is used exclusively for system maintenance and executing main frame diagnostics.

A peripheral of the terminal processor that deserves special attention is the television character and vector generator. This device, under control of the terminal processor, converts character

codes and line drawing commands into composite video TV pictures -- outputting new pictures at a rate of up to 60 per second. The device has a programmable character definition memory that at any one time may contain over 500 character definitions. Thus, the terminal processor can rapidly change character fonts to suit different authoring styles and languages. Included also is a graphic generating device that draws lines between given coordinates simultaneously with the generation of alpha-numeric characters.

3.0 TICCIT COMMUNICATIONS

In the early work on TICCIT, it was recognized that existing CAI and computer based information systems suffered from:

(1) Awkward and expensive communications links from the terminals to the computer, or,

(2) Expensive terminals to overcome limitations of telephone grade communications links, or

(3) Moderately priced terminals that were severely limited in capability because of a telephone link to the computer.

TICCIT's solution to the communications problem will allow not only inexpensive high-capability terminals to be placed conveniently in a school, but also in homes and businesses. TICCIT uses a wideband coaxial cable (the same type as used in CATV) to distribute signals to the terminals and carry responses back to the computer. TICCIT, in some circumstances (such as in a junior college) might have a dedicated cable system, but, in most cases it would utilize a spare channel on a CATV system.

TICCIT can send displays to over 100 simultaneous interactive users on a single cable TV channel. This is done by the TICCIT computer facility assembling a single field TV picture for a terminal, adding to the picture an address specifying the terminal and then injecting the picture into the cable system as a regular TV field (in a 60th of a second). In this way, 60 individual displays can be transferred from the computer to the terminals per second.

The address of each picture is a binary code of sixteen black and white dashes, appearing immediately before the vertical retrace period. The mask on a normal TV receiver covers the line on which the code appears, making it invisible. In Figure 3, a TICCIT home

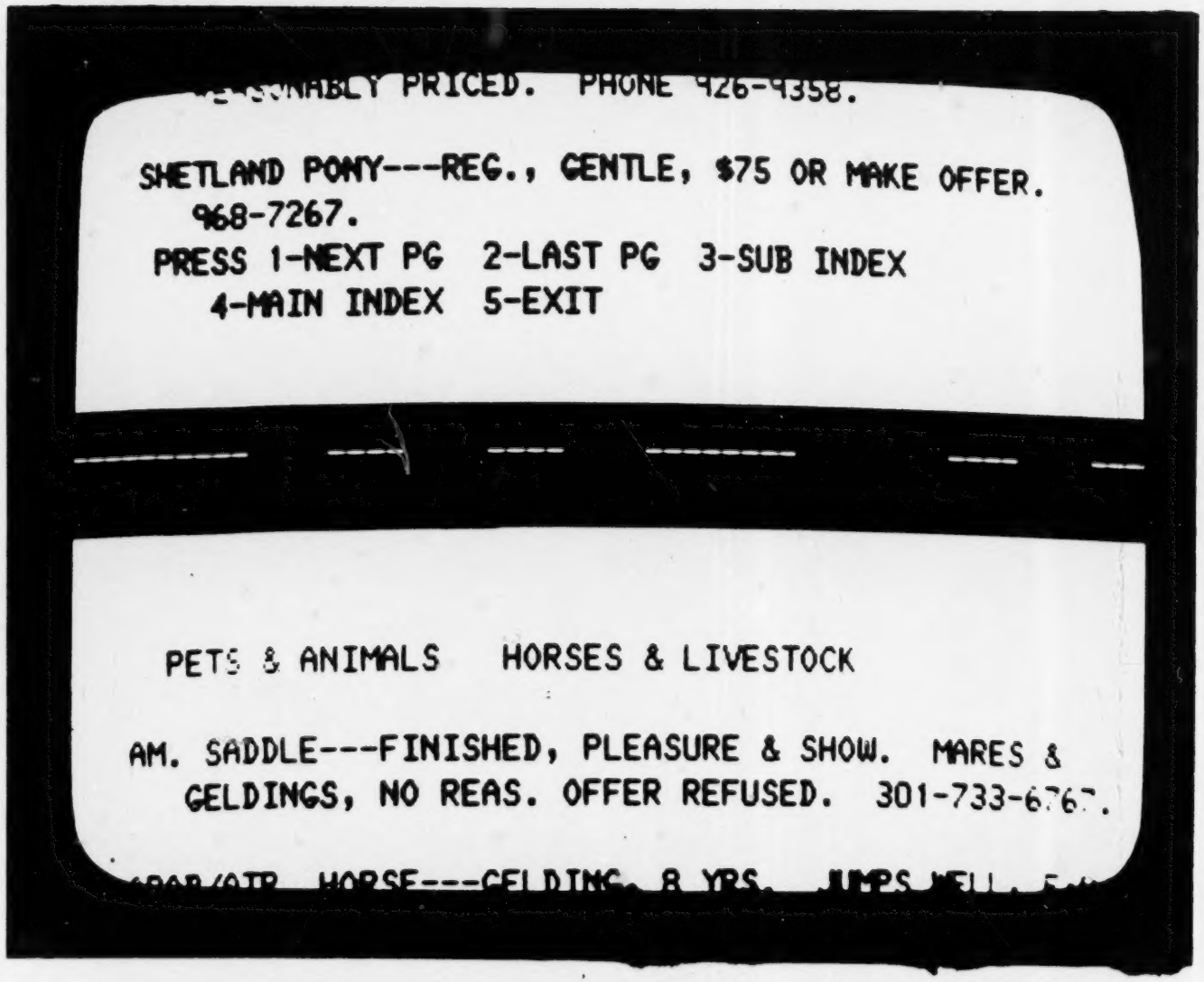
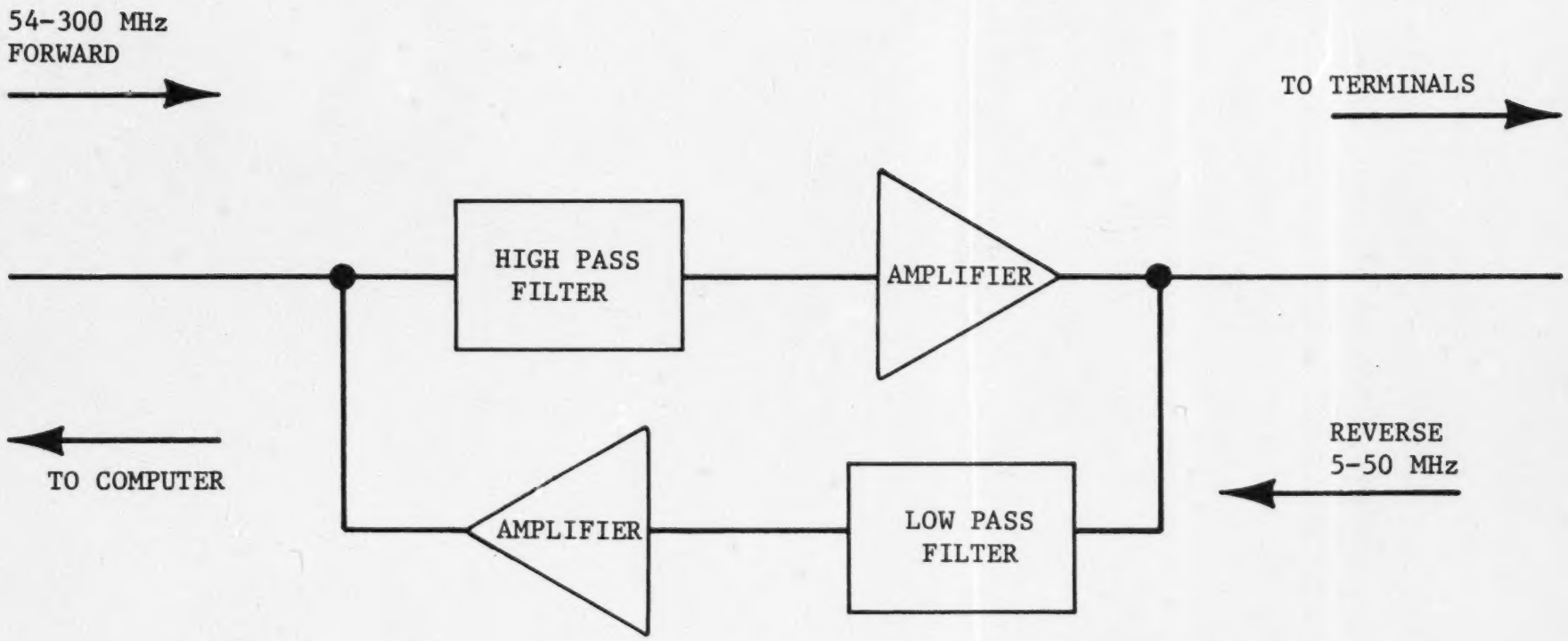

SONABLY PRICED. PHONE 926-9358.
SHETLAND PONY---REG., GENTLE, $75 OR MAKE OFFER.
968-7267.
PRESS 1-NEXT PG 2-LAST PG 3-SUB INDEX
4-MAIN INDEX 5-EXIT
PETS & ANIMALS HORSES & LIVESTOCK
AM. SADDLE---FINISHED, PLEASURE & SHOW. MARES &
GELDINGS, NO REAS. OFFER REFUSED. 301-733-6767.

FIGURE 3
TYPICAL TICCIT DISPLAY WITH VERTICAL SYNCHRONIZATION DISPLACED TO SHOW ADDRESSING CODE SIGNAL

television terminal screen is shown after the masking has been removed.

CATV systems have, in the past, carried signals in one direction only (from the head end or signal origination point to all of the subscriber's homes). New CATV systems are being designed and built with two-way signal flow capability. While TICCIT can use any of the several return signal flow approaches that have been designed, it would, in a dedicated system, use a frequency division multiplexing approach as shown in Figure 4. Frequencies above 50 MHz would be allowed to pass and be amplified in the forward direction (to the subscribers). Signals from 5 to 50 MHz would be allowed to pass and be amplified in the return direction.

TWO WAY CABLE
(FREQUENCY DIVISION MULTIPLEXING)



TICCIT REQUIRES: 6 MHz BANDWIDTH IN FORWARD DIRECTION
.5 MHz BANDWIDTH IN REVERSE DIRECTION

FIGURE 4
TICCIT TERMINAL BLOCK DIAGRAM

4.0 THE MULTIMEDIA TICCIT TERMINAL

The TICCIT terminal "on line" is a computer terminal with alphanumeric and graphic display capability. "Off line", it can play prerecorded lectures, display closed circuit TV presentations and standard TV broadcasts.

Each of the newly designed TICCIT terminals combines still or video taped motion display, optional voice output, and keyboard input, to permit two-way conversation between user and computer. The systems for producing all three of these functions were designed to prevent any one of them from becoming an economic bottleneck, (since the system cost of terminals is multiplied by 128 -- the number of users simultaneously served). It is only because of recent developments in hardware technology that all these functions may now be achieved at low cost.

A TICCIT terminal uses a standard television receiver, a video tape recorder, and keyboard and control electronics. (See Figure 5). The video tape recorder (VTR) serves as the TV refresh memory. The video tape recorder is driven by a composite video signal coming from the television receiver. It, in turn, provides composite video to the TV for display. The control electronics portion of the hardware examines line 265 of each received picture field and compares the black and white pattern with the address pattern set in the decoder (a distinct code for each terminal). If, and only if, the transmitted picture's address matches the decoder's address will the control electronics place the recorder in the record mode for the entire next picture frame (slightly less than 1/60th of a second). At the completion of the frame, the recorder is placed back in the playback mode. Keyboard signals are time division multiplexed by the control electronics onto the same cable that carries RF video signals to the terminal.

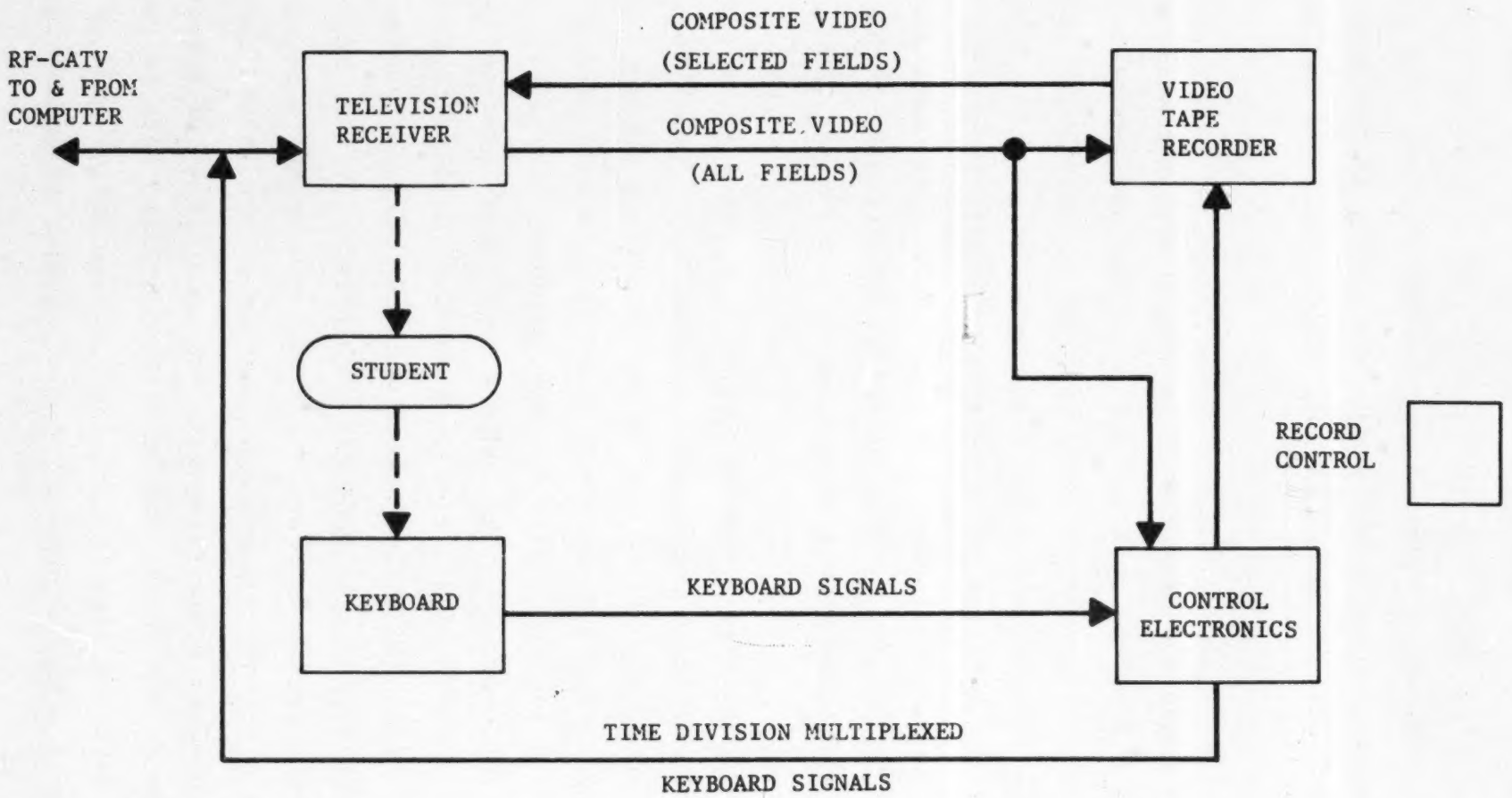


FIGURE 5
TICCIT TERMINAL BLOCK DIAGRAM

In the next year, several companies will be introducing cassette video tape recorders, initially costing $700 to $800; later, according to company reports, the price will fall to $400 to $500. The relatively low cost of these new units, along with their ease of use and their entertainment value (and the recorded material being prepared for mass dissemination), leads MITRE to think that they will be a market success.

During this past summer, we have demonstrated and tested a home-oriented version of this terminal (see Figure 6) in Reston, Virginia. The results of these tests and demonstrations have been encouraging in two ways. First, we have found the terminal to be reliable. Even though the system is only at the advanced breadboard state, we have conducted tests and demonstrations on almost a daily basis with a minimum of "bugs". Secondly, we have been overwhelmed by the response of government and industry officials to the implications of home application of TICCIT.

FIGURE 6
TICCIT TERMINAL INSTALLED IN HOME

5.0 STYLISTIC AUTHORING LANGUAGES

The authoring system being developed for TICCIT is designed to provide for the efficient production of large volumes of educational material. The technological key to this large-scale production is an efficient means of transforming the material from a form with which the author is comfortable into a form that can be processed on the computer system. This problem has many similarities to that of turning a textbook manuscript into the printing plates used to mass produce the copies of a book. For the textbook, the author's form consists of handwritten or typed pages that are transcribed for proof-reading and mechanized processing.

The educational material prepared for TICCIT might also by submitted by the author in handwritten or typed form and transcribed for proofreading and mechanized processing. However, the TICCIT educational material not only consists of data, such as the text of the book, but also, of instructions to the computer. These instructions include the time at which data is to be shown to a student, what to do when a student answers a question correctly, what to do when a student answers a question incorrectly, and what to do when the student wishes to get supplemental information. The English language, while natural to the author, is ill suited to communicating such information to the computer because of the multiplicity of ways in which an idea can be stated and because of ambiguities in the way the language is often used.

Previous methods that have been used to communicate the desired information to the computer is to make use of a special purpose language that strikes a compromise between what an author might find natural and what is easily processed by the computer. Here, authors are required to learn and use the special language and the computer, of course, is required to process material that is correctly prepared

in the language.

We, in the TICCIT project, have chosen a different approach. Rather than impose a special language on authors, we are developing the tools needed to process a wide variety of authoring styles. These tools will allow us to respond to the authoring forms preferred by individual authors so long as the material is complete and unambiguous. The use of these tools results in languages tailored to the individual author's style. Different authors can use different styles, and an author can adopt different styles for different subjects.

As shown in Figure 7, the tools being developed for the stylistic authoring languages consist of a general purpose programming language called TICCIT Language, and secondly, a powerful macro-language processor. This macro-language processor will be used to convert the material prepared by the author into the TICCIT language computer program. The form used by the author might be, for example, a form consisting of pages showing the information to be displayed to the students and tables listing possible answers with the response to be made to each answer.

The general-purpose programming language, called TICCIT Language, would be used to provide the basic operations needed to implement the macros or functions the authors have implicitly or explicitly used. The TICCIT Language does not have functions (or macros) such as "count the number of commas in the student's response" built into it but, rather, it has the logical, arithmetic, string and list processing capabilities needed to implement such a function. Also, the TICCIT Language allows such functions to be programmed as subroutines which can be called upon as needed. A library of generally useful routines will be built and these routines used as needed in the course modules.

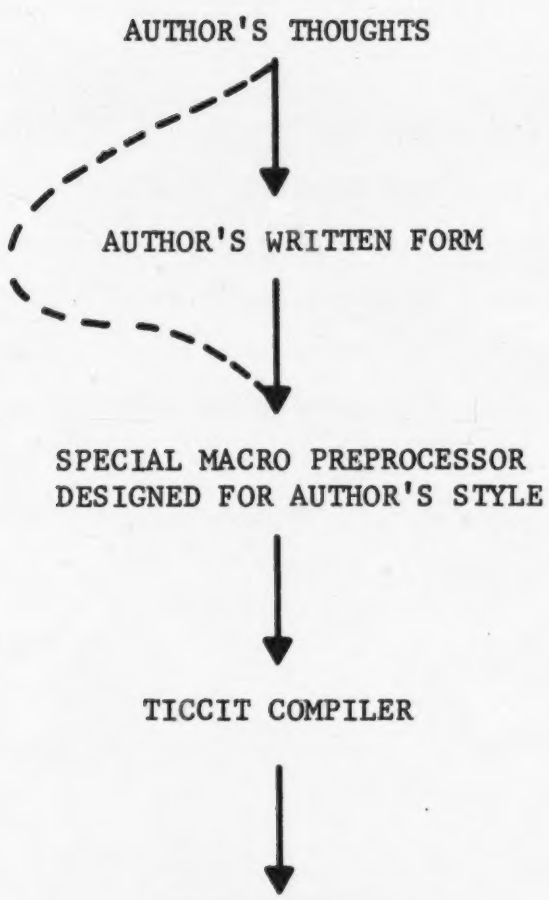


FIGURE 7
THE TICCIT STYLISTIC LANGUAGE COMPILATION PROCESS

6.0 SUMMARY

In summary, The MITRE Corporation's TICCIT (Time-Shared Interactive Computer Controlled Information Television) is a system for which component hardware and software have been selected with the aim of making mass utilization economically feasible. To keep the initial purchase price to the user low, a "stand-alone minicomputer" supporting a few hundred terminals is contemplated, allowing for expansion by adding additional minicomputer units. Costs per terminal compare favorably with the most optimistic projections for large-scale centralized systems.